Hermetic Package for Optical & Other Space MEMS

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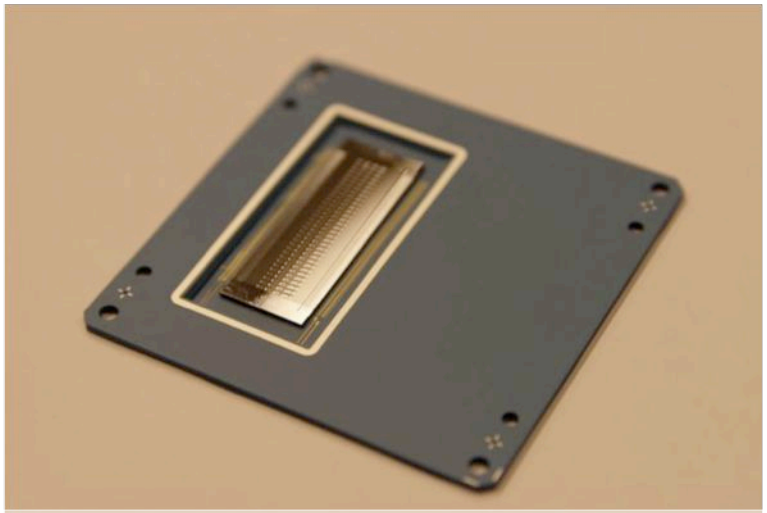

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IMAPS CICMT Munich, Germany, 21-24 April 2008

Presentation outline

- Description of the problem - requirements
- Description of the developed solution
- Main design challenges
- Main processing challenges
- Conclusion
- Outlook

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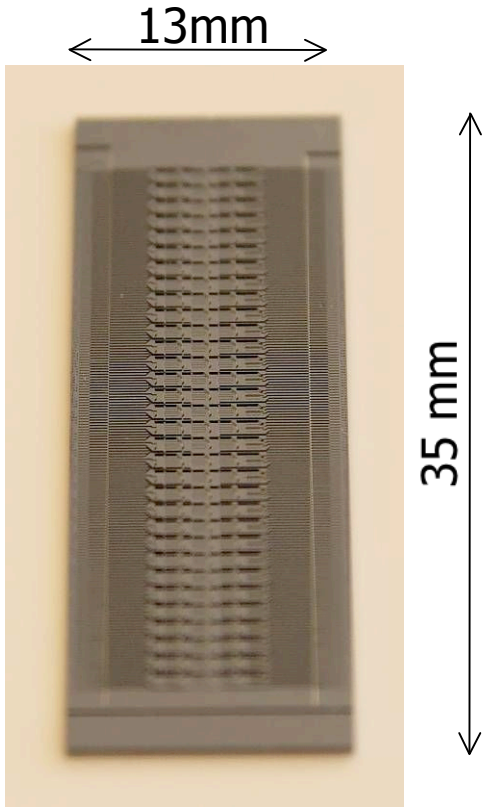
Functions to be fulfilled

- Complex electrical interface (386 connections)
- Optical window with anti-reflective coating
- Mechanical positioning
- Atmosphere control: mechanical damping
- Packaging with low thermal budget
- Small to medium production volumes
- Flexible design process



MOEMS electrode chip

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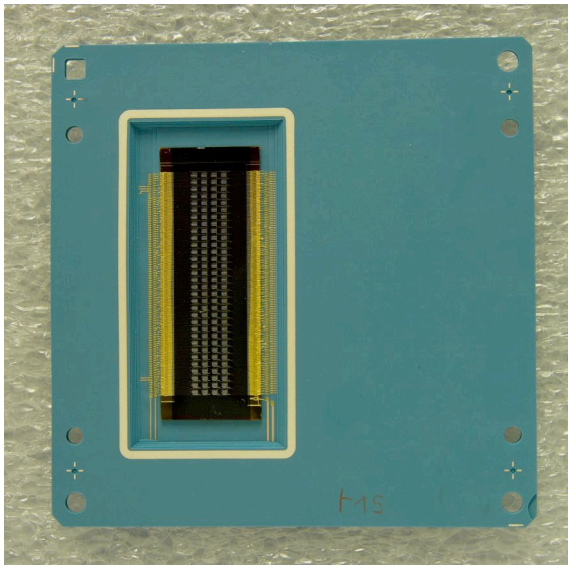
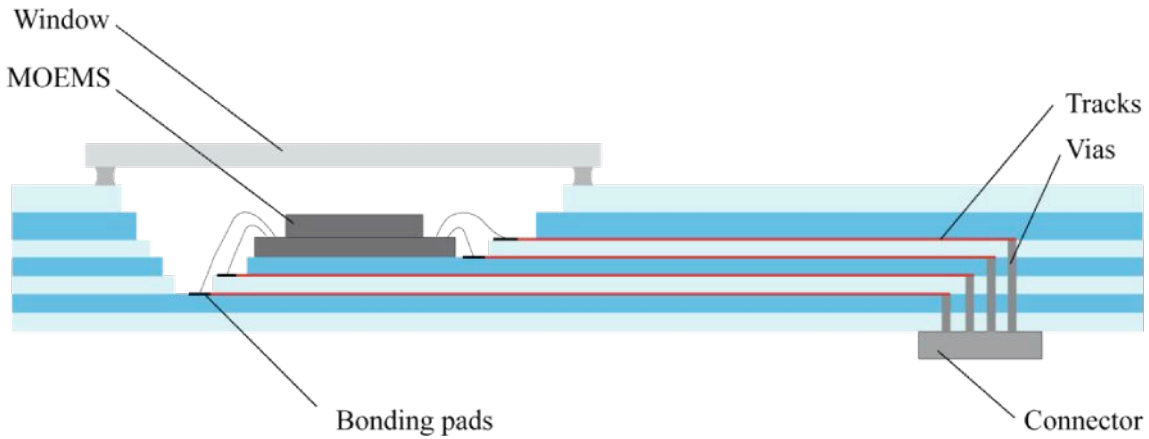
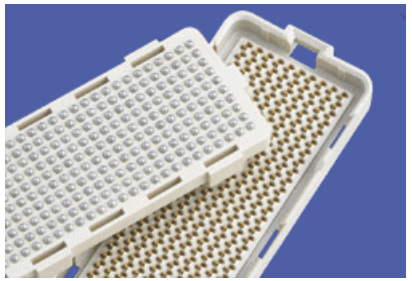
Developed solution

- 10-layer LTCC package
- BGA connector (MegArray 400-pin)
- Au wire bonding between chip electrodes and LTCC package
- Co-fired, buried Ag-Pd tracks and vias + Au bonding pads
- Glass lid soldered with low thermal budget







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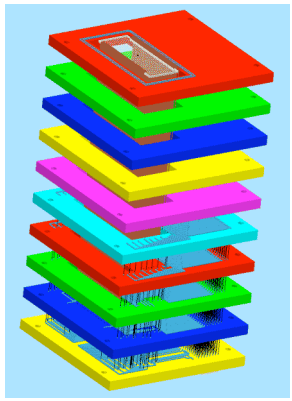
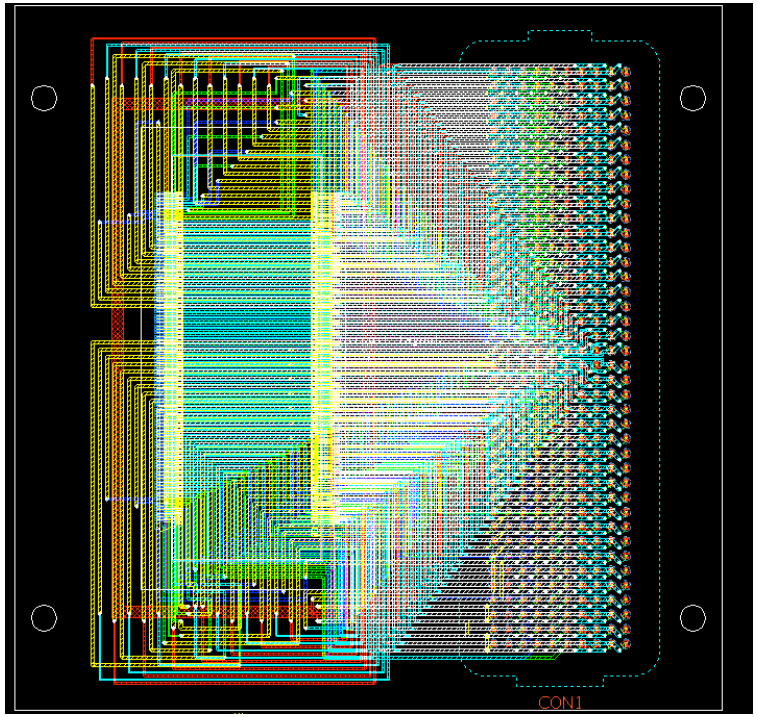
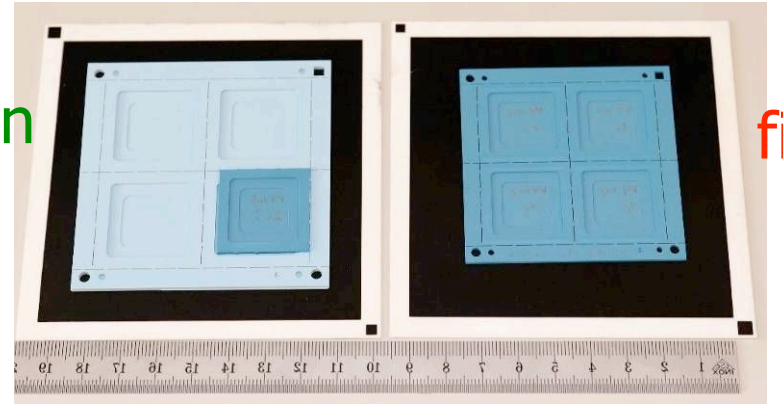
Main design challenges

- 10-layer package
  (complex routing with specialised software)
- Large number of connections
  (high density)
- Shrinkage of LTCC during firing

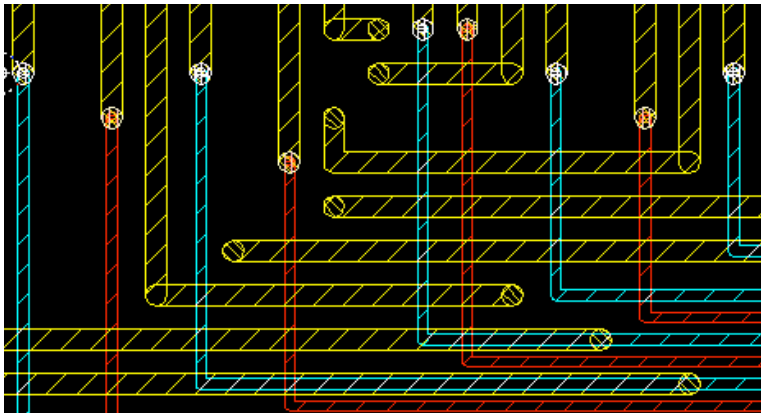




green

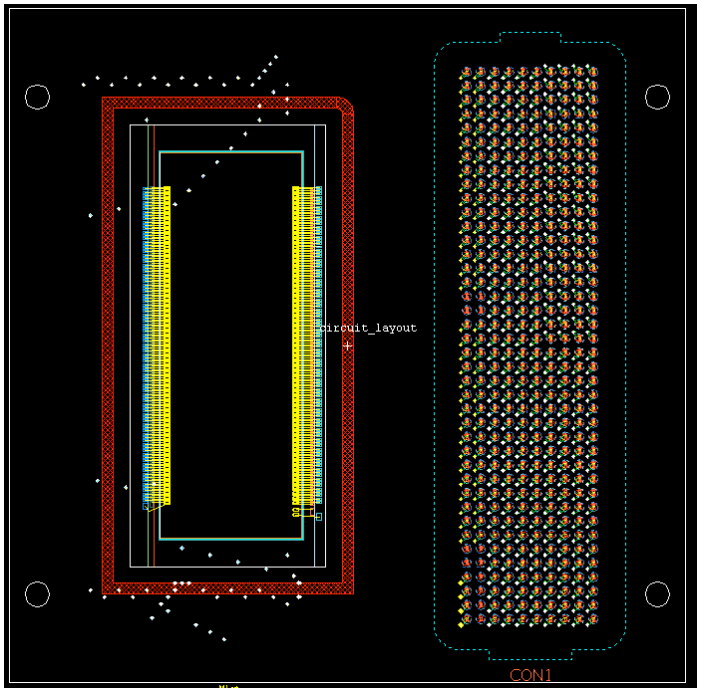


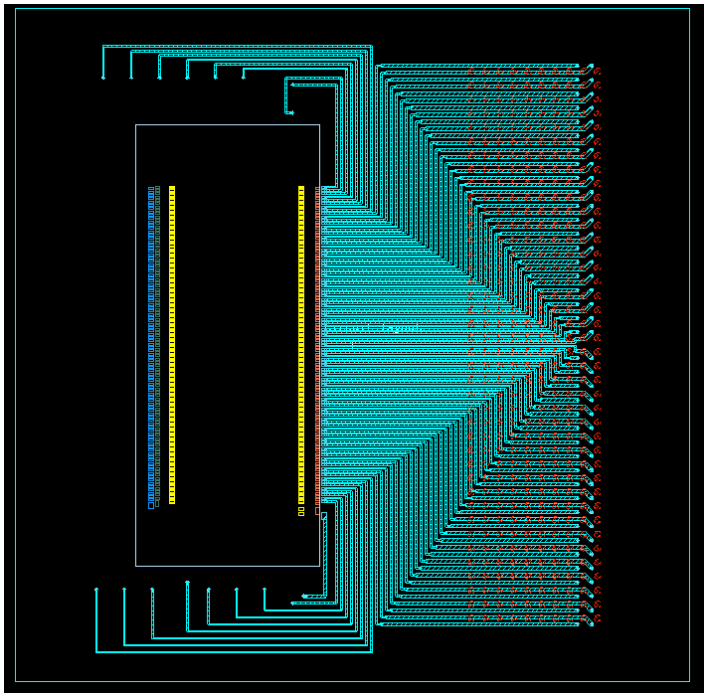
fired



Main design challenges

- Problem:
  - Pitch of bonding pads on electrode: 150 μm
  - Pitch of screen printing, minimum: 300 μm
- Solution:
  Bonding pads of the package need to stand on 2 layers
  on each side of the electrode chip -> 4 layers altogether





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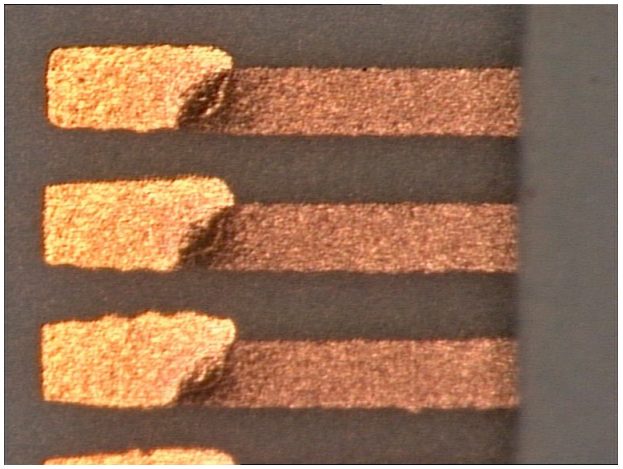
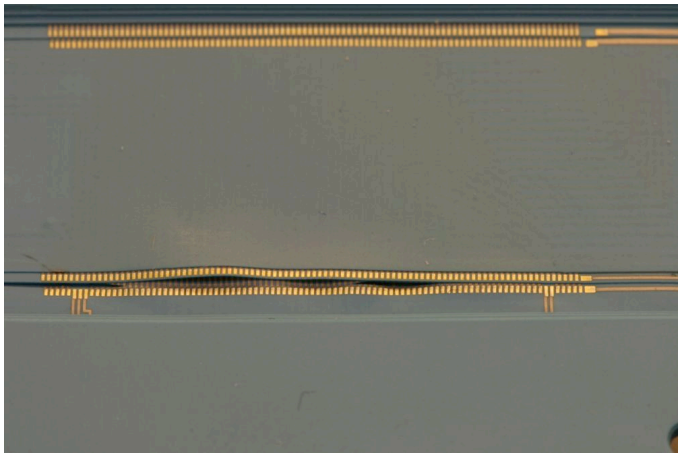
Main processing challenges

- Finest resolution of screen printing: 150 μm line / 150 μm space
  - Up to 3 different screen-printing layers need to be aligned
- Paste choice: compatibility (esp. Ag:Pd with Au)
  - bonding pads (Au)
  - tracks (Ag / Ag:Pd)
  - vias (Ag / Ag:Pd)
  - metallisation for soldering (Ag / Ag:Pd, cofired / postfired)

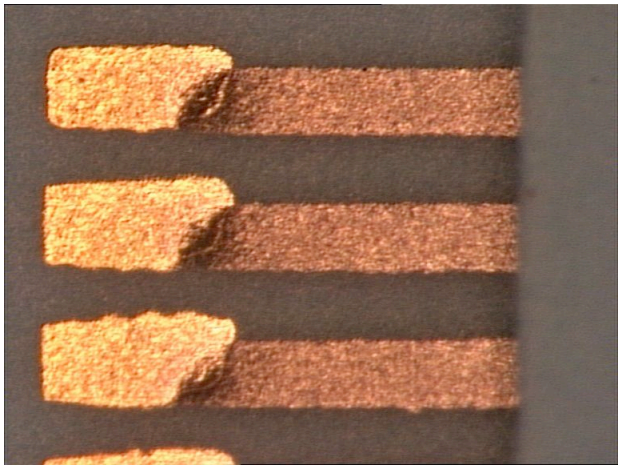
Many tests were needed to determine the best behaviour.

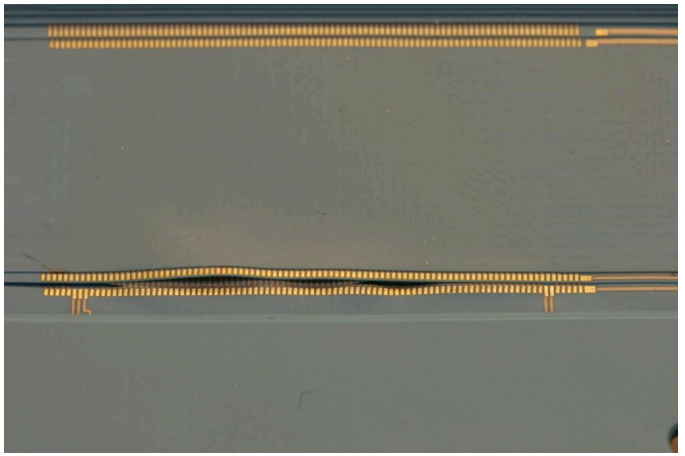




Main processing challenges

Type	Paste	Material	Result
Via Fill (a)	**DP 6141**	**Ag**	**OK**
Via Fill (b)	DP 6138	Ag:Pd	OK too
Tracks (a)	DP 6145	Ag	Poor wettability
Tracks (b)	**DP 6146**	**Ag:Pd**	**OK**
Bonding Pads (a)	**DP TC502**	**Au**	**OK**
Bonding pads (b)	DP 5472	Au	**Incompatible**





Laser cutting & screen-printing

Tapes 1 to 10, ready for stacking and lamination

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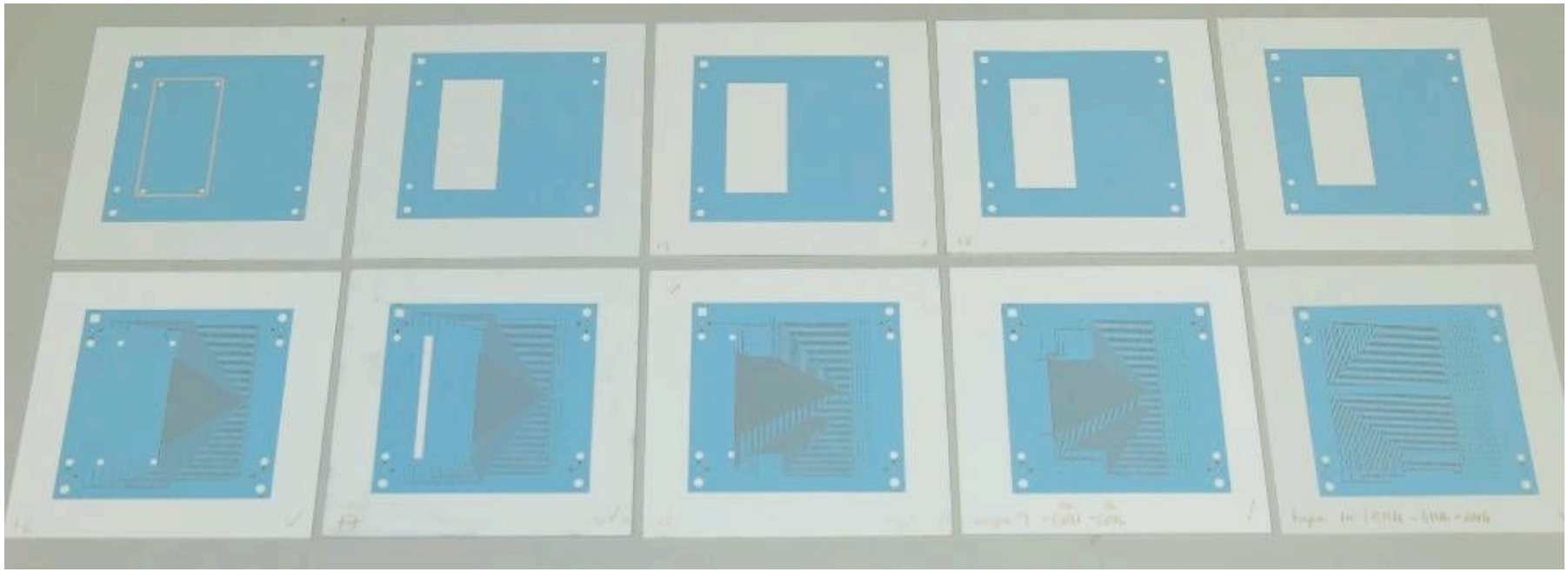

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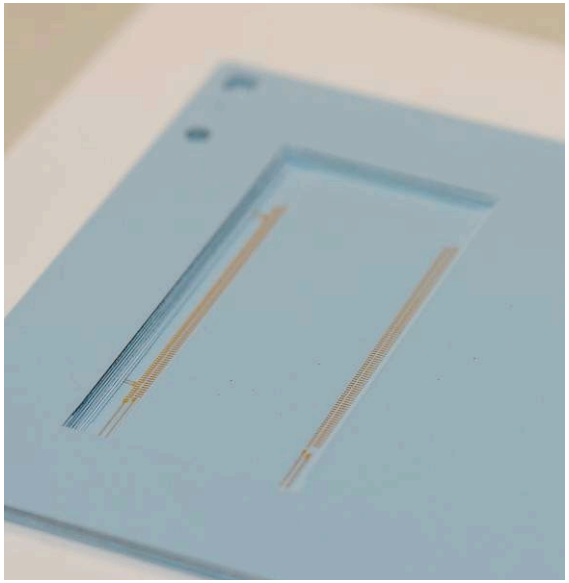
\+ 1x laser cutting

* 1x screen-printing

Main processing challenges

- High track density -> impact on lamination and shrinkage
- Deep cavity with steps -> improved lamination technique

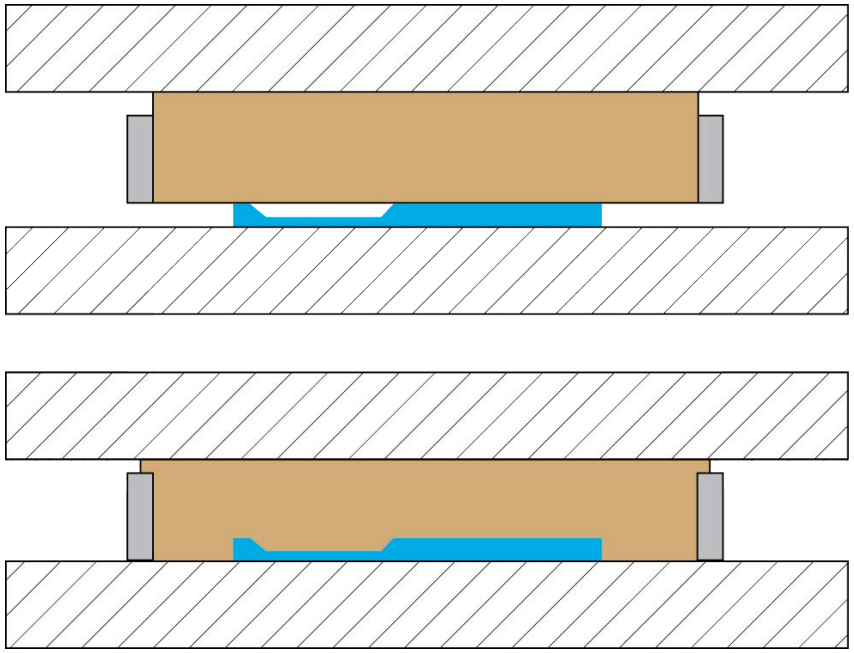


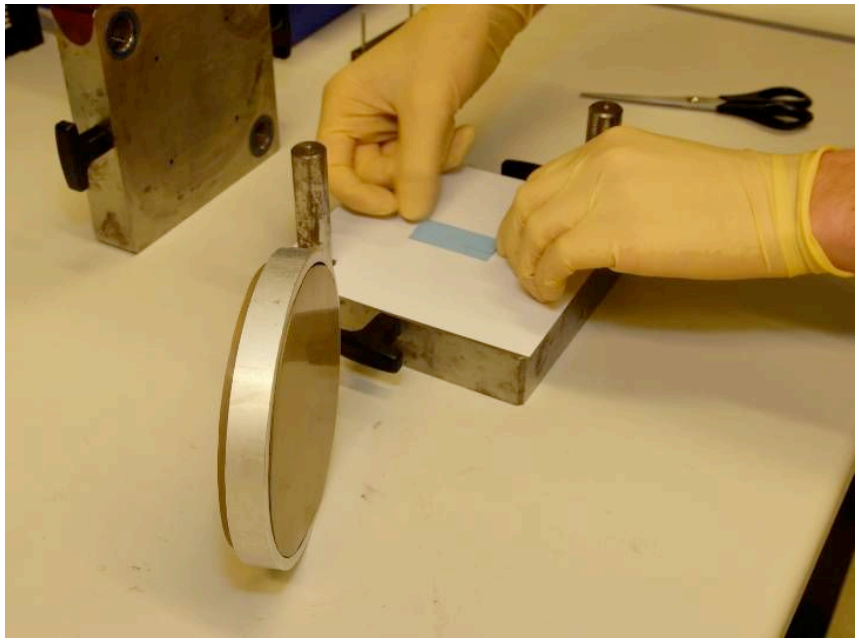
Cavity in LTCC for MOEMS chip

"Pseudo-isostatic" pressing of LTCC

Pseudo-isostatic lamination

- Use of a rubber plate to laminate the bottom of the cavity
- Constrained rubber plate to avoid x-y deformation of the LTCC
- Rubber inserts to improve homogeneity of the pressure
- 80 bar, 25°C, 10 minutes → less deformation, but lamination critical
- Simple process, reproducible





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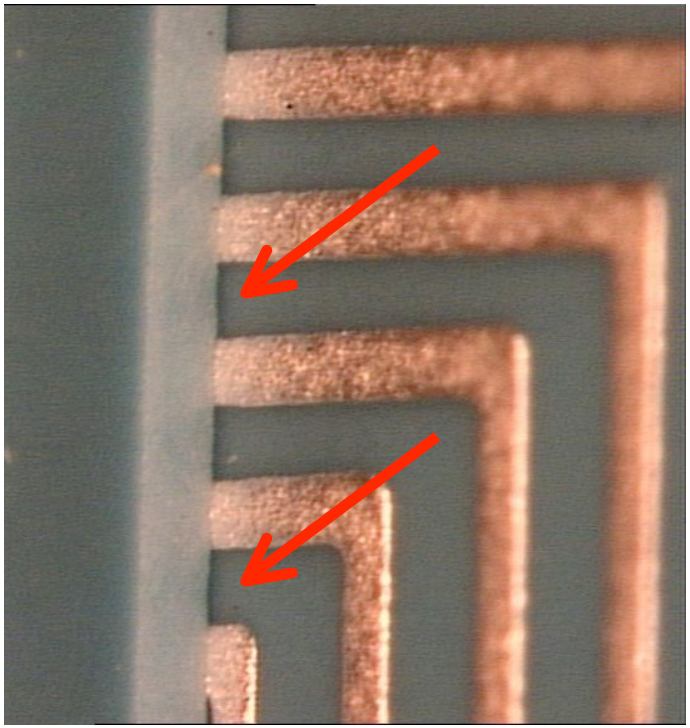
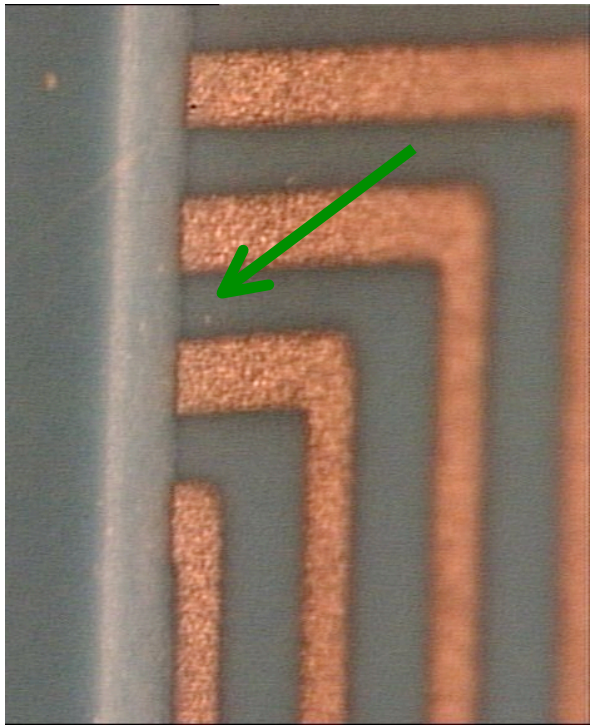


Bad lamination between rigid metal plates

Pseudo-isostatic lamination



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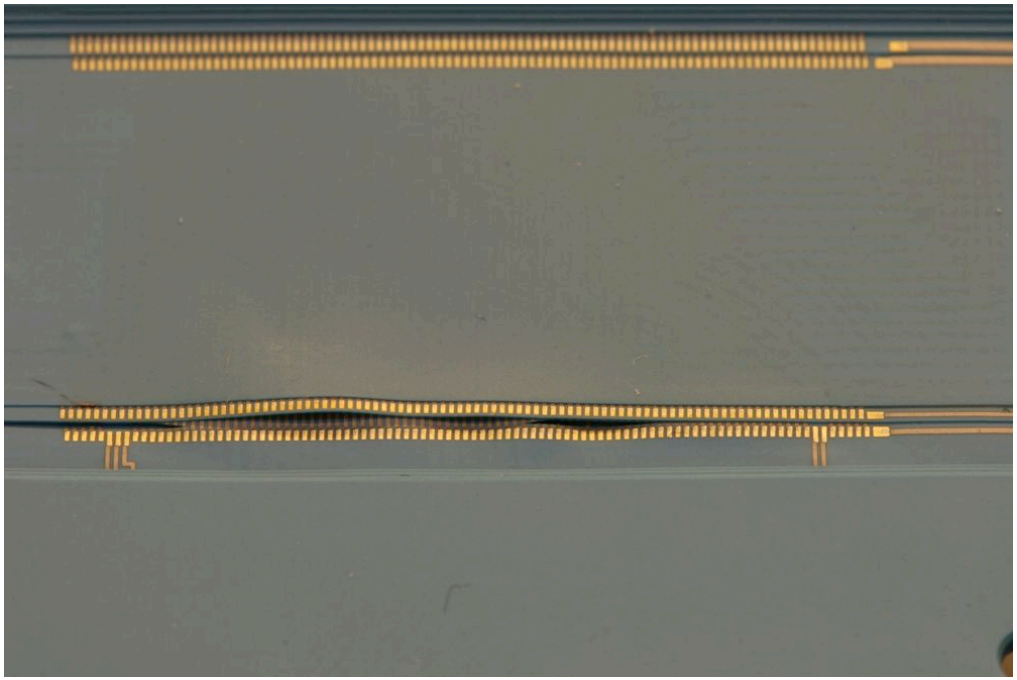
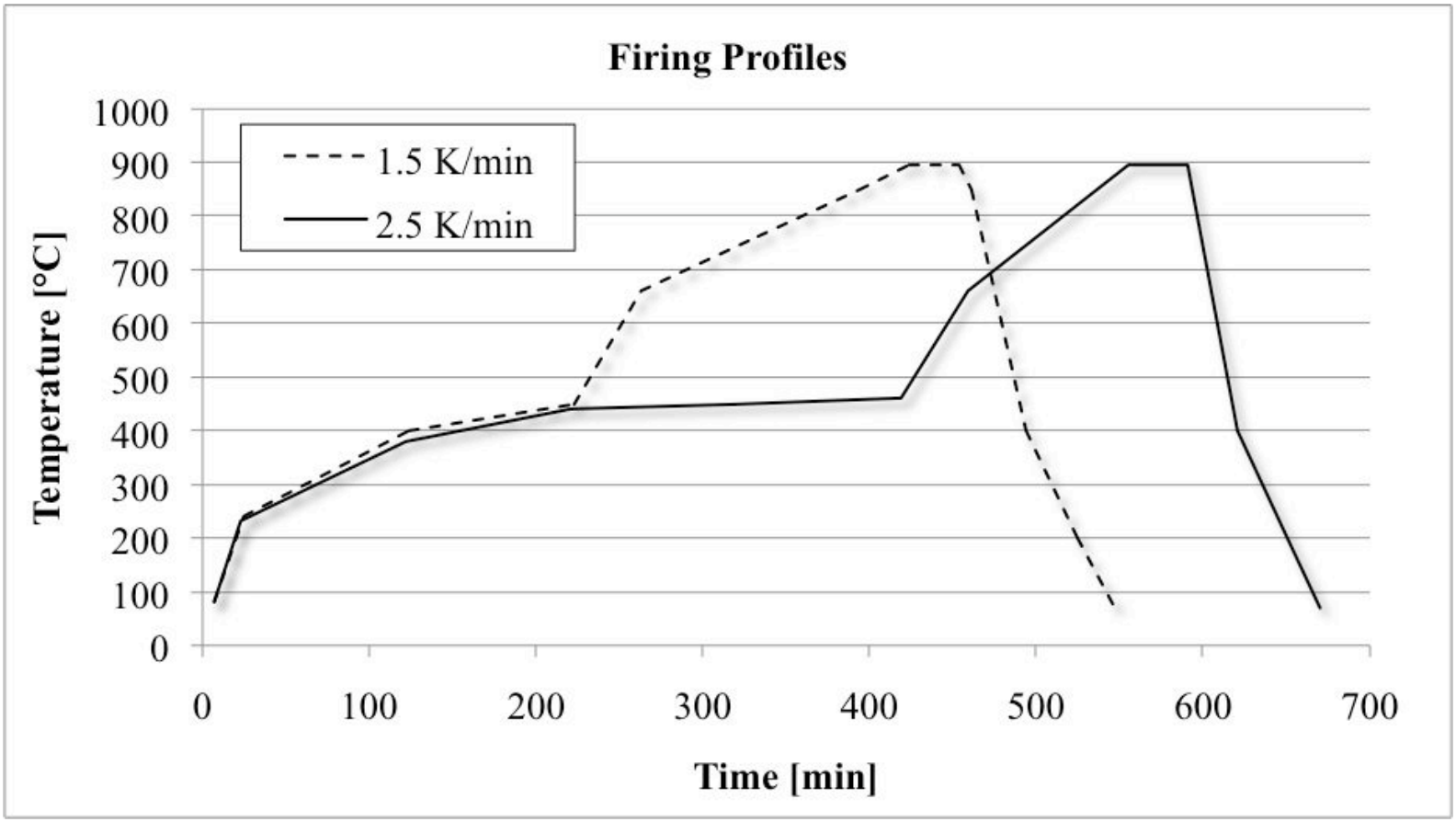


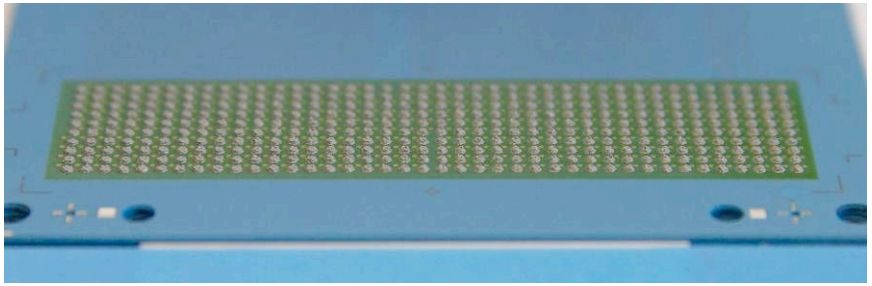
Separation due to insufficient lamination of layers

Firing profile

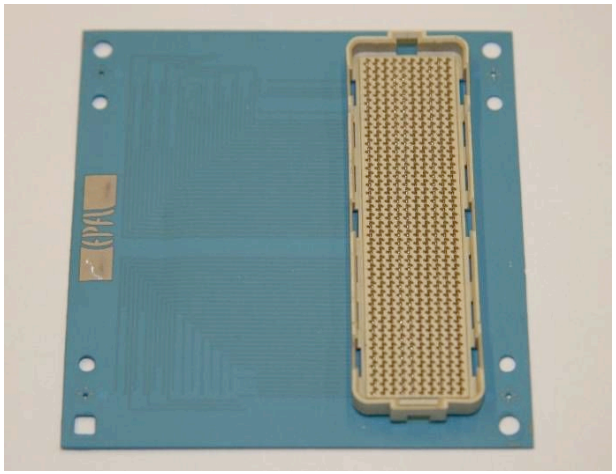
- Firing in air, 400 l/h, sintering ramp 2.5 K/min
- Peak temp @ 875°C (oven set @ 896°C)



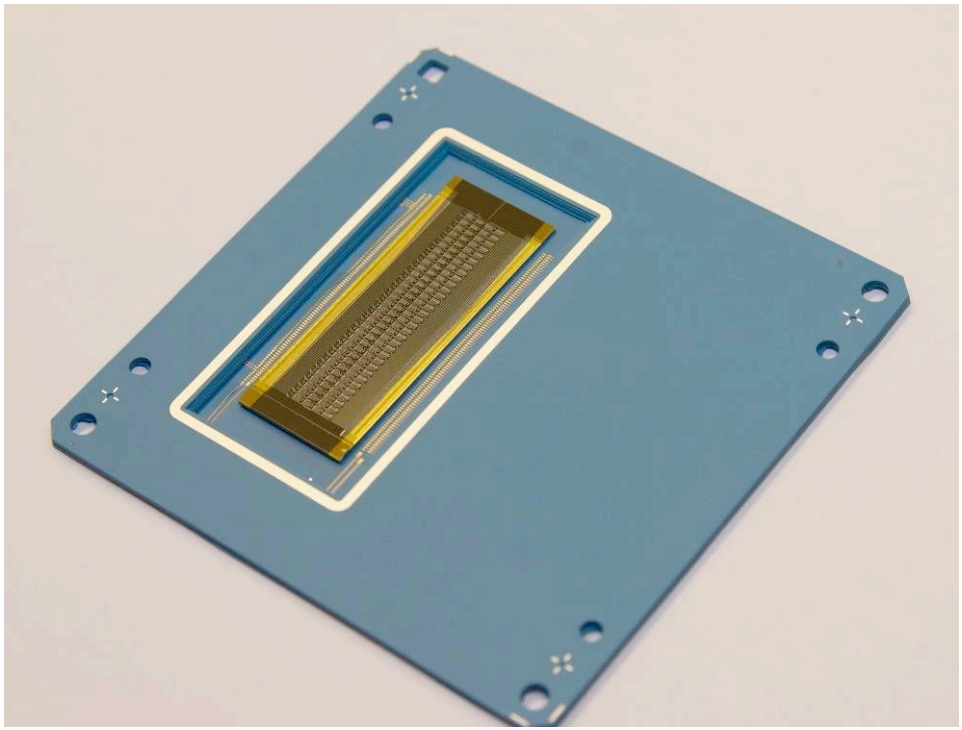
Firing and post operations



Glaze (solder mask) & solder for MegArray

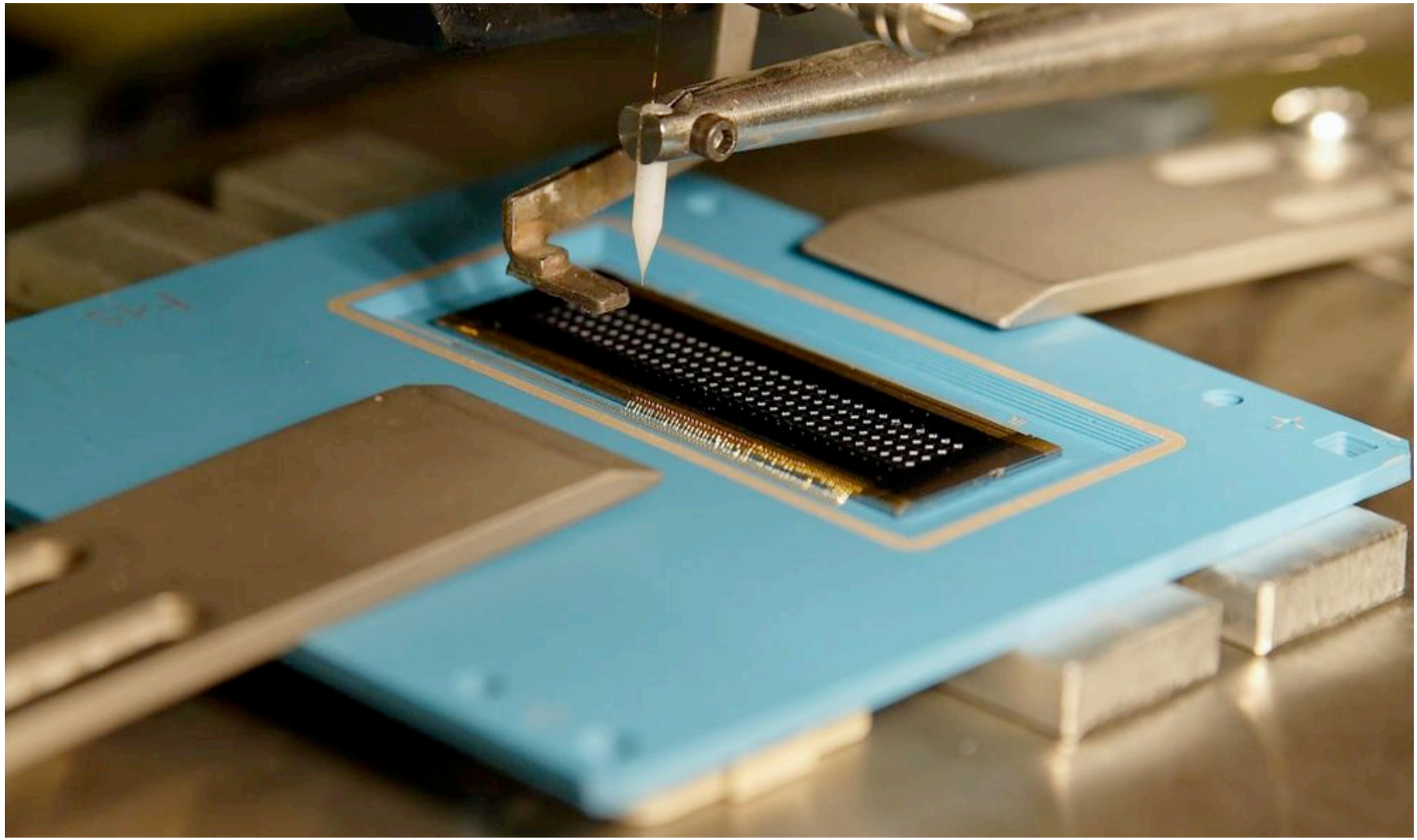


Soldering of MegArray + Sn-Bi bumpin of seal ring



Gluing of MOEMS

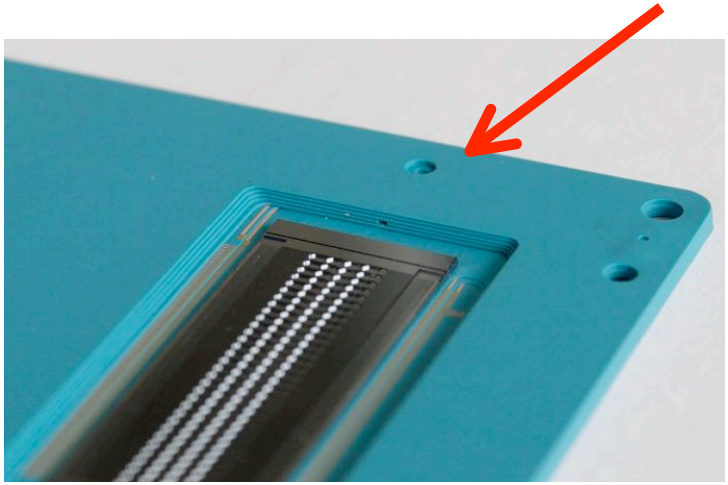
Ball bonding of electrodes chip (Au-25μm)

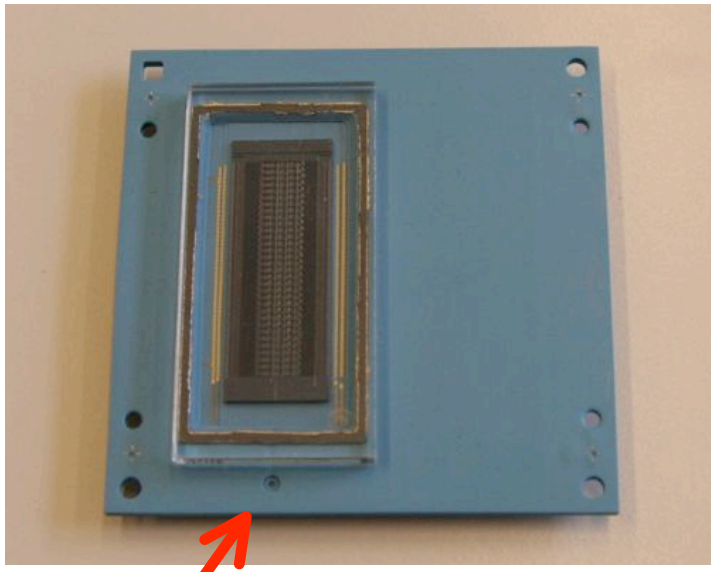


Sealing

- Glass with temperature-sensitive anti-reflective coating → thick-film metallization cannot be applied
- Thin-film metallization: Ti (20nm) – Pt (200nm) – Au (50nm)
- Sn-Bi solder reflow @150°C → low thermal impact
- Laser heating can be used to further reduce thermal impact
- Venting channel to prevent « bubbling » due to differential pressure

→ closed later with local laser heating





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Conclusion

- Simple, pragmatic packaging technology for complex MOEMS
- Routing all 386 connections to one connector is not optimal

→ **Should be symmetrical : two connectors**

- More testing needed
- Creep of Sn-Bi in service due to differential pressure?

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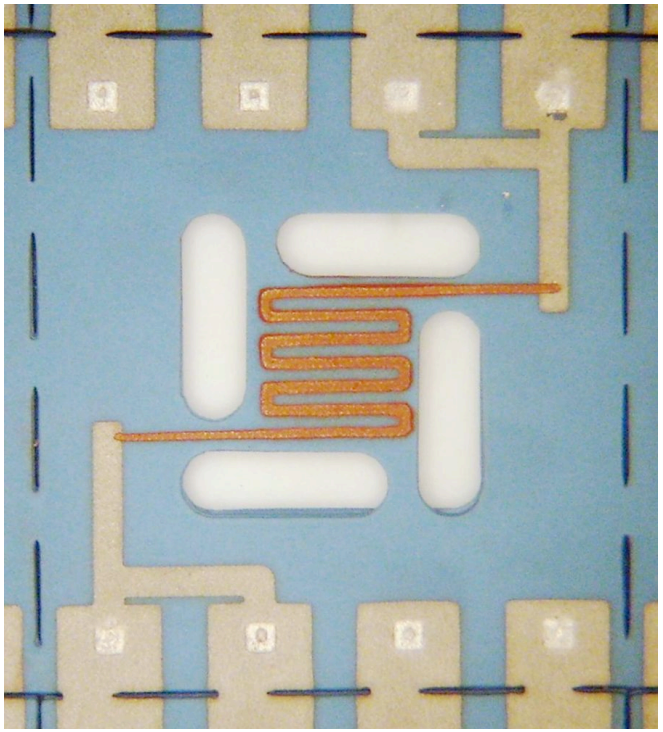
Outlook: MOEMS package

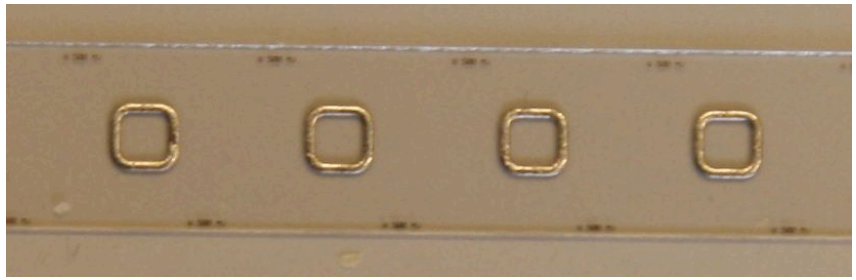
- Hermeticity measurement
- Measurement of electrical connection yield
- Redesign of the routing:
  - Use of more than one connector
  - Symmetrical package routing



Outlook: Packaging for Atomic Clock

- Goals:
  - Hermetic package with a small quantity of Rubidium (Rb)
  - Low sealing temperature (Rb is liquid at 40°C; high vapor pressure)
  - Protective atmosphere needed (Rb reacts with O_2 and H_2O)

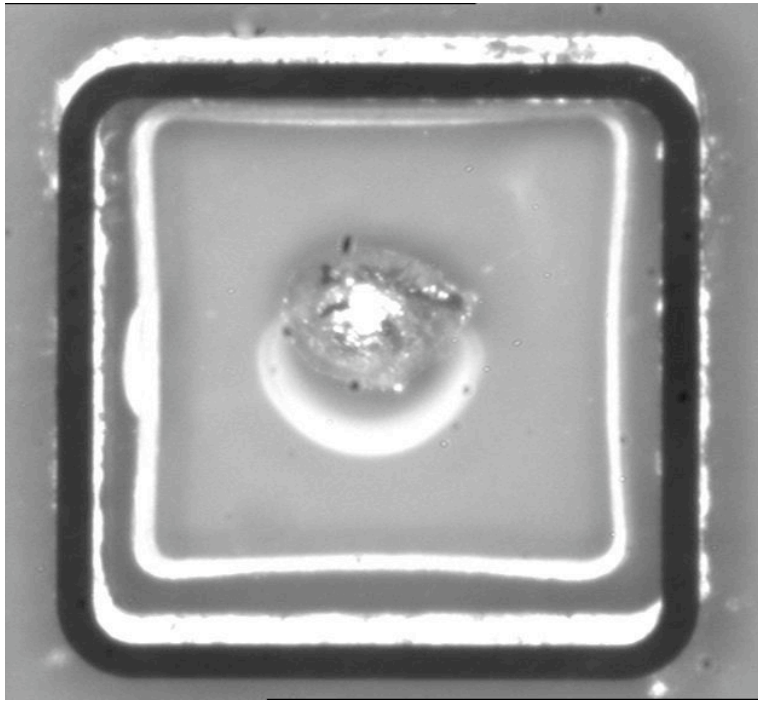
- Solution:
  - Soldering of two glass plates with Sn-Bi eutectic solder
  - A metallization ring (thin-film Ti – Pt – Au) is evaporated onto the glass and pre-bumped with Sn-Bi

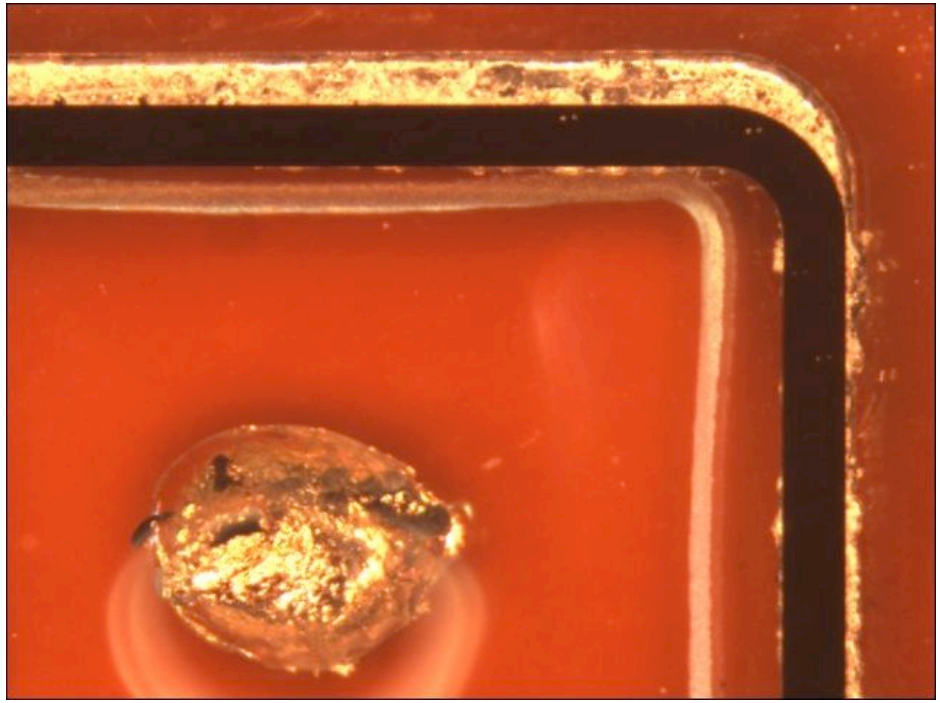


Metallized & bumped (Ti-Pt-Au + Sn-Bi) sealing rings

Outlook: Packaging for Atomic Clock

- Goal: to obtain a hermetic package including a small quantity of Rubidium (Rb)





The End

Thank you for your attention!